Initial Studies of the Directional Reflectance Changes in Pressed and Sintered PTFE Diffusers Following Exposure to Ionizing Radiation

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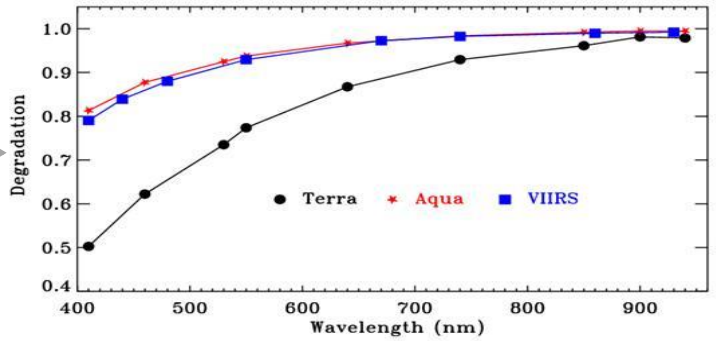
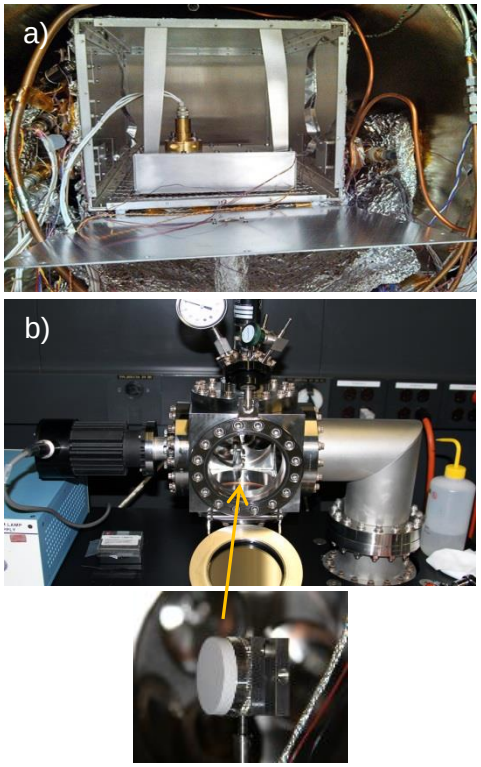
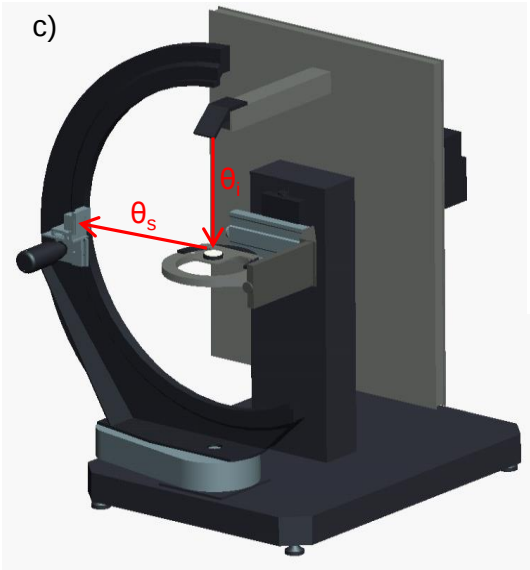
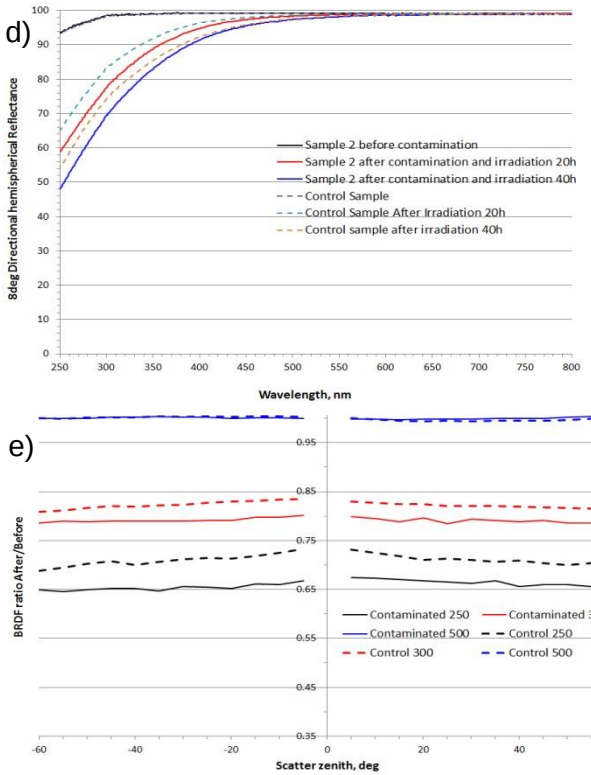
Polytetrafluoroethylene (PTFE, a.k.a. Spectralon™) solar diffusers, commonly used in the on-orbit radiance calibration of visible through shortwave infrared remote sensing instruments, experience wavelength-dependent reflectance degradation over time.



Our laboratory assessments of the effects of VUV irradiation on diffuser reflectance provide quantitative insight into this on-orbit degradation.







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References:

G.T. Georgiev, J.J. Butler, K.J. Thome, L.A. Ramos-Izquierdo, L. Ding, L.J. Graziani and G.A. Meadows, ''Initial studies of the directional reflectance changes in pressed and sintered PTFE diffusers following exposure to contamination and ionizing radiation", Metrologia **51** (2014) S319–S328, doi:10.1088/0026-1394/51/6/S319

Data Sources: NASA GSFC Code 618 Diffuser Calibration Laboratory (DCaL) PTFE Bidirectional Reflectance Distribution Function (BRDF) and Directional Hemispherical Reflectance (DHR) Measurement Data; NIST BRDF Calibration reports; MODIS Terra and Aqua and SNPP VIIRS Solar Diffuser Degradation Data;

Technical Description of Figures:

Top Figure: On-orbit reflectance degradation of MODIS Terra, MODIS Aqua, and SNPP VIIRS PTFE diffusers from launch to September 2015.

Bottom Figure: NASA GSFC Diffuser Calibration Laboratory-based experimental procedure to examine the reflectance degradation of PTFE diffusers as a function of contamination and vacuum ultraviolet exposure. a) The thermal vacuum bakeout/contamination chamber: All PTFE samples undergo initial vacuum bakeout followed by the option of contamination/deposition (i.e. 45Å) of Pennzane™, a common spacecraft lubricant. b) The oil-free vacuum ultraviolet (VUV) exposure chamber: Contaminated and uncontaminated PTFE samples are mounted in the chamber and irradiated by the black VUV light source on the left. c) The PTFE samples are measured for BRDF before and after bakeout, contamination, and VUV exposure using the DCaL's out-of-plane scatterometer and for Directional Hemispherical Reflectance (DHR) using the DCaL's Perkin Elmer spectrophotometer. d) DHR versus wavelength data for contaminated (i.e. sample 2) and non-contaminated (control) samples before and after 20 and 40 hours of VUV irradiation. e) Ratio of the normal incident (BRDF at 250nm, 300nm, and 500nm before and after 20 hours VUV irradiation for contaminated sample 2 and the control.

Scientific significance, societal relevance, and relationships to future missions:

On-orbit calibration of Earth remote sensing instruments is required to discriminate between instrumental changes and changes in earth physical processes under study. The majority of remote sensing instruments operating in the visible through shortwave infrared wavelength region employ solar illuminated diffusers for on-orbit radiance calibration. Polytetrafluoroethylene (PTFE), also known as Spectralon™, is a white, near-Lambertian, diffuse scattering material commonly used for this purpose. Unfortunately, the presence of on-orbit contaminants coupled with incident solar radiation at ultraviolet wavelengths, leads to wavelength dependent degradation of the reflectance of PTFE diffusers.

The work presented here is part of a larger study designed to examine PTFE reflectance degradation as a function of wavelength of incident light, mission solar exposure time, and contaminant amount. Bruegge and Stiegman (1) examined the aging of PTFE deployed on the Space Shuttle but did not examine its dependence as a function of incident solar wavelength. The results presented here show an impact of VUV irradiation from 115 to 165nm on PTFE diffusers as manifested by non-negligible changes in their measured directional reflectance from 250nm to 400nm. Previous studies performed in our lab revealed that irradiation above 180nm over typical mission exposure times produced changes in the directional reflectance of uncontaminated PTFE less than our 1% (k=1) BRDF measurement uncertainty.

Results from this study is of interest to government, university, and industry remote sensing scientists and engineers. Information from this work aids in the optimal design of on-orbit solar diffuser calibration systems, provides guidance into minimizing pre-launch and on-orbit contamination, and provides quantitative insight into the development and refinement of instrument radiometric math models from which calibration and instrument measurement uncertainties are derived.

(1) Stiegman, A.E., Bruegge, C.J., and Springsteen, A.W. 1993 Ultraviolet stability and contamination analysis of Spectralon diffuse reflectance material Opt. Eng. **32** 799-804.